A comparison of the impact of different additives on the cation exchange capacity of fresh water drilling fluid

Bichakshan Borah* · Borkha Mech

Dept. of Petroleum Technology, Dibrugarh University, Dibrugarh 786004, Assam, India

✉ Bichakshan Borah
rs_bichakshanborah@dibru.ac.in
Borkha Mech
borkha2014@dibru.ac.in

ABSTRACT

In order to optimise its rheological and filtration qualities, drilling fluids are often composed of an aqueous clay suspension, weighting material, and various chemicals, salt, polymers, etc. The Cation Exchange Capacity (CEC) refers to the capacity of clay minerals or soil to absorb cations in a form that allows them to be readily exchanged for other cations present in an aqueous solution. Since bentonite is the primary viscosifying clay mineral in the drilling fluid, determining the CEC is a crucial test in determining the quality of commercial bentonites. With the use of a Methylene Blue Test kit (MBT), the CEC value of a drilling fluid is ascertained. When analyzing colloidal stability, CEC determination is crucial. A stable colloid is much more effective than the unstable ones. This test can be used to observe and study the stability of drilling fluid, a colloid. In this study, drilling fluids are made using bentonite and a variety of additives, including barite, various salts, and hydroxide, such as NaCl, KCl, and NaOH, and their CEC values are measured. These salts and barite have been found to have no effect on the CEC value of drilling fluid, although NaOH did. After ageing for a few days, the drilling fluid's CEC value is examined.

Keywords: Drilling mud, Bentonite, cation exchange capacity, methylene blue test.

1. INTRODUCTION

Any drilling operation's success depends heavily on the choice and use of the drilling fluid. A continuous liquid or gaseous phase containing various types of solids, liquids, and gases known as drilling fluid is cycled through a wellbore during a drilling operation [Ekeigwe et. al;.2012]. Chinese drilling techniques for finding hydrocarbons used water-based drilling fluids as early as the third century BC to assist the ground penetrate. While in the US at Spindle Top, the word "mud" was first coined. In order to lubricate the drill, drillers drove a herd of cattle through a field that had been wet down [Nasser et. al. 2013; A. Rajesh Kanna et. al. 2017]. Drilling fluids are used for a variety of operations, including the removal of rock fragments from beneath the bit and transporting them to the surface, controlling formation pressure by applying enough hydrostatic pressure to subsurface formation to prevent formation fluid from flowing into the well bore, cooling and lubricating drilling equipment and subsurface tubular, sealing of pores and other openings by forming filter cake, etc [Mr Hamed Behnamanhar et. al. 2014; Mohamed Khodja et. al. 2010]. One of the viscosifying agents used in drilling fluid is bentonite, which is also combined with other weighting components, various chemicals, polymers, etc. It is impossible to overemphasized how essential bentonite is to drilling operations as a drilling fluid. In relation to the entire cost of drilling a well, drilling fluid saves costs by about 15%, which is significant [B. B. M. Dewu, 2012]. Bentonite is a type of rock that is created when volcanic ash is devitrified in place. It is made up of extremely colloidal and plastic clays made up of smectite and montmorillonite [Parker S.P, 1988]. Only while or after deposition in an aquatic environment does bentonite formation, or the change of volcanic ash to bentonite, occur [Grim R. E. 1968; Patterson S.H. and Murray H.H, 1983]. Bentonite has a cation exchange capacity (CEC) and a hydrophilic quality. The chemical makeup of the bentonite pore structure determines its adsorptive potential. The bentonite is intercalated with surfactants that can interact with the interlayer surface's negative charge in order to boost its ability to bind organic molecules. Bentonite has a surface chemical complex that results from its capacity to form a thixotropic water gel, the layered structure and ability of the cation exchange high, high surface area, high water absorption, and contains aquartz crystal, cristobalite, feldspar, or other compounds [Uddin, F., 2008]. The obtained CEC value will be influenced by the mineral composition.

Measurement of the exchangeable cations in clays is done using the Cation Exchange Capacity (CEC). Clay particles that are negatively charged are balanced by the positively charged exchangeable cations. Exchange ions typically include sodium, calcium, potassium, iron, and manganese. CEC is measured in milliequivalents per 100 grammes of clay (meq/100 grammes). The CEC in the oil and gas sector is assessed using the Methylene Blue Test Capacity Test (MBT), which is advised by the API. Other techniques, such as a colorimetric technique based on cobalt hexamine trichloride depletion, an ammonium acetate saturation method, copper complexes method, etc. are also available to measure the CEC value (Mike et al. 2009). The clay sample is mixed with water, a small amount of dispersant, sulphuric acid, and hydrogen peroxide before being heated, cooled, and titrated with methylene blue solution. When a drop of the sample suspension placed on filter paper turns a faint blue colour, it has reached its destination. With the least amount of equipment, the CEC value can be determined at the well site and in a laboratory.

In this research, drilling fluids are made with bentonite as the primary clay particle, the primary viscosifying agent, and the primary weighting agent. The bentonite drilling fluid is mixed with various salts, including NaCl and KCl, to measure the CEC value. To observe the same, the drilling fluid is also mixed with one alkaline solution, NaOH. The samples of drilling fluid were then aged, and their CEC value was once more evaluated.

2. MATERIALS AND APPARATUS EMPLOYED

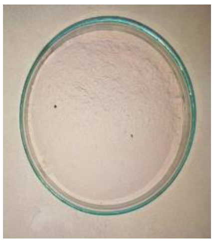
In this experiment, drilling mud sample preparation uses bentonite as the primary clay component. In drilling fluid, bentonite is also employed as a viscosifier. Barite is the weighing substance that is employed. In this experiment, NaCl and KCl are the two types of salt that are being employed. Here, NaOH, or an alkaline solution, is used. The drilling fluid is made by combining each of these ingredients with distilled water. The MBT kit, which includes a syringe, Erlenmeyer flask, sulphuric acid, hydrogen peroxide, a hot plate, methylene blue solution, and a glass rod, is also needed as well as a beaker, stirrer, weight scale, stand mixer (in this case, a Hamilton Beach mixer), filter paper, and the MBT kit.

3. METHODOLOGY

The purpose of this study is to investigate how different additives affect a drilling fluid's CEC value. The main components of this work are divided into the following stages.

In the first stage of the experiment, different amounts of bentonite were measured using a weight balance and then added to distilled water that was stored in a beaker, depending on the concentrations. The sample was thoroughly mixed in the Hamilton beach mixer for around 3 to 4 minutes after being stirred for a few minutes with a stirrer. Four drilling fluid samples were made using solely bentonite, with concentrations of 2%, 5%, 8%, and 10%. The CEC of the solid particle present in the fluid was measured using the MBT kit after it had been thoroughly mixed. 2.0 ml of drilling fluid were added to the Erlenmeyer flask using a syringe. Prior to injection, any air or gas that was present in the drilling fluid was eliminated. The drilling fluid was swiftly drawn into the syringe after being agitated to break up the gel. The drilling fluid was then gradually emptied back into the drilling fluid while maintaining the syringe's submerged tip. The drilling fluid was then precisely 2.0 ml drawn into the syringe once more and injected into the flask. The Erlenmeyer flask received 10 ml of distilled water before receiving 15 ml of 3% hydrogen peroxide and 0.5 ml of 5N sulfuric acid, respectively. Using the hot plate, the sample was gently boiled for 10 minutes. After that, the mixture was diluted with distilled water to make roughly 50 ml. In the flask, the methylene Blue solution was poured in 0.5 ml portions and stirred for around 30 seconds (Dohrmann, 2009). After swirling it, one drop of the sample was dropped into the filter paper with the help of a glass rod. The methylene blue solution was added in increments of 0.5 ml in each step until the drop appeared as a blue-turquoise ring surrounding a dyed solid in the filter paper. When it formed, it indicated the initial end point of the titration. The flask containing the sample was shaken for an additional two minutes when the blue tint halo expanding from the area was noticed, and another drop of the sample was applied to the filter paper. The final endpoint was revealed when the blue ring reappeared. When the blue ring failed to form, 0.5 ml increments of the methylene blue solution were added until, when a drop was collected after two minutes, it revealed a blue tint halo.


(a)


(b)


(c)


(d)


(e)


(f)


(g)


(h)


(i)

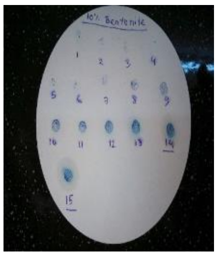

(j)

Fig. 1. Additives and apparatus used in the experimental work. (a) Bentonite, (b) Barite, (c) NaCl, (d) KCl, (e) NaOH, (f) weight balance, (g) Hamilton Beach Mixer, (h) Drilling fluid sample, (i) MBT kit, (j) Filter paper

The equation provides the methylene blue capacity, which is used to express the cation exchange capacity of the mud

Methylene Blue Capacity = Volume of Methylene Blue Used / Volume of mud used

The cation exchange capacity of clays can be expressed as milliequivalents of methylene blue per 100g of clay [Bilal et. al. 2016].

4. RESULTS AND DISCUSSION

The tables below presents the CEC values for the drilling fluid samples. These values are also plotted in graph below.

Table 1. CEC value of bentonite drilling fluid

Sl. No.	Amount of bentonite (in %)	CEC value (meq/100g)		
		Day 0	Day 3	Day 7
1	2	71.00	71.00	71.00
2	5	71.50	71.50	71.50
3	8	73.25	73.25	73.25
4	10	74.25	74.25	74.25

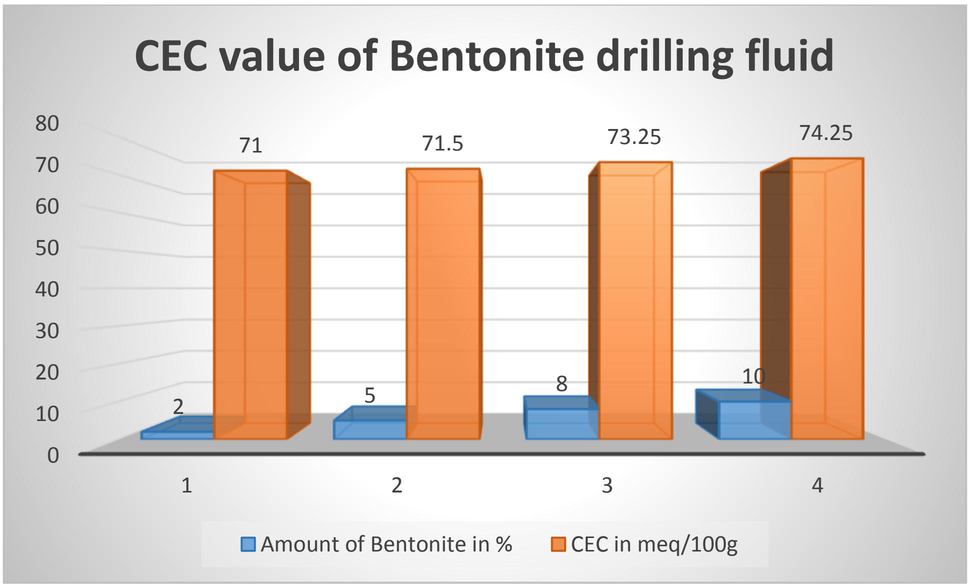


Fig. 2. CEC value of bentonite in drilling fluid

The CEC values of the bentonite are higher than 70 meq/100g, as can be seen from the obtained data. When the amount of bentonite in the drilling fluid rises, the CEC values also rise a small bit. The CEC achieved ranges from 70 to 100 meq/100 g for bentonite, with the lowest value of CEC obtained for 2% of bentonite being 71.00 and the highest value obtained for 10% of bentonite being 74.25. The CEC value, however, wasn't affected over time as it displays the same outcome. A 5% concentration of bentonite mud is taken as base mud.

Table 2. CEC value of barite in the base bentonite drilling fluid

Sl. No.	Amount of barite (in g)	CEC value (meq/100g)		
		Day 0	Day 3	Day 7
1	2	72.25	72.25	72.25
2	5	72.25	72.25	72.25
3	8	72.25	72.25	72.25
4	10	72.25	72.25	72.25

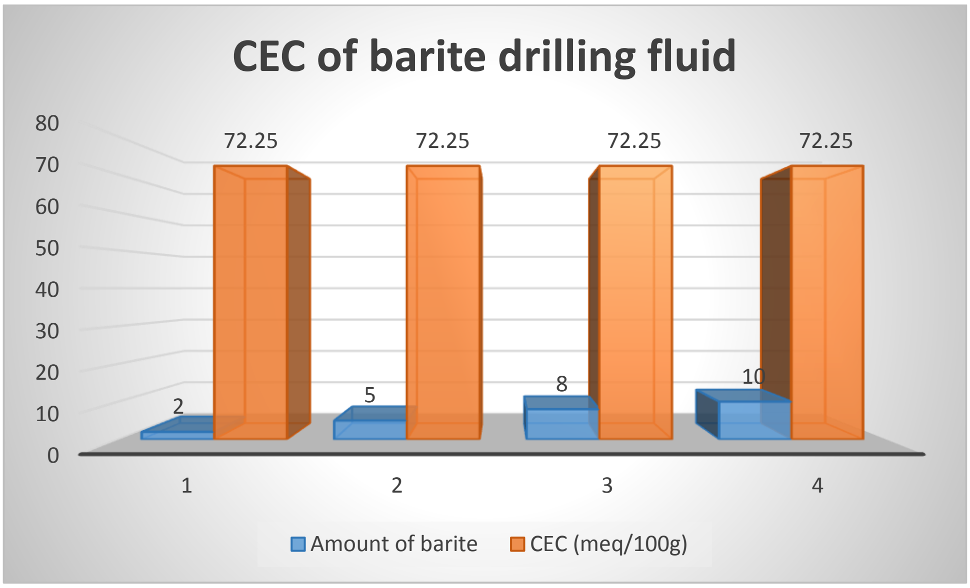


Fig. 3. CEC of Barite drilling fluid

Table 3. CEC value of NaCl in the base Bentonite drilling fluid

Sl. No.	Amount of NaCl (g)	CEC value (meq/100g)		
		Day 0	Day 3	Day 7
1	2	72.25	72.25	72.25
2	5	72.25	72.25	72.25
3	8	72.25	72.25	72.25
4	10	72.25	72.25	72.25

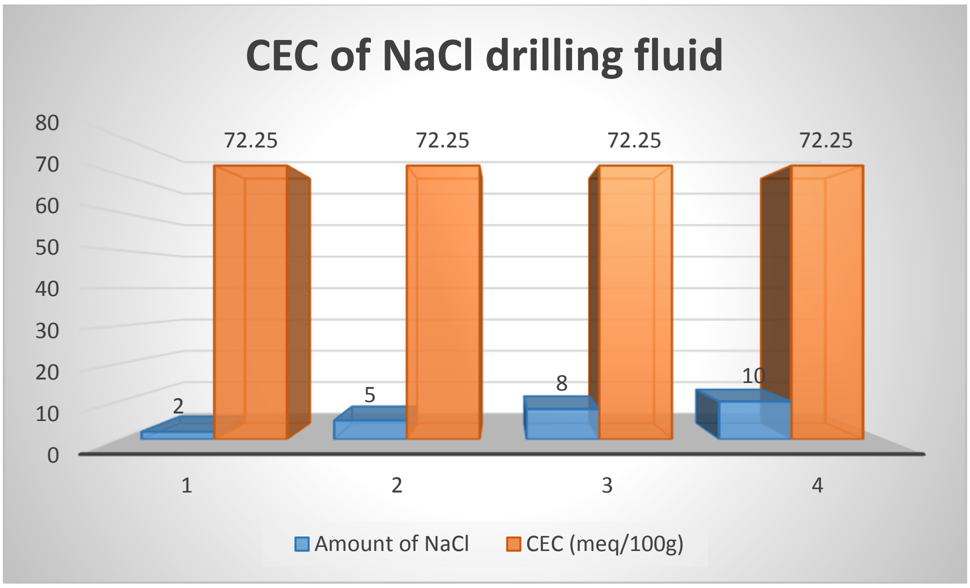


Fig. 4. CEC of NaCl Drilling fluid

Table 4. CEC value of KCl in the base bentonite drilling fluid.

Sl. No.	Amount of KCl (g)	CEC value (meq/100g)		
		Day 0	Day 3	Day 7
1	2	72.25	72.25	72.25
2	5	72.25	72.25	72.25
3	8	72.25	72.25	72.25
4	10	72.25	72.25	72.25

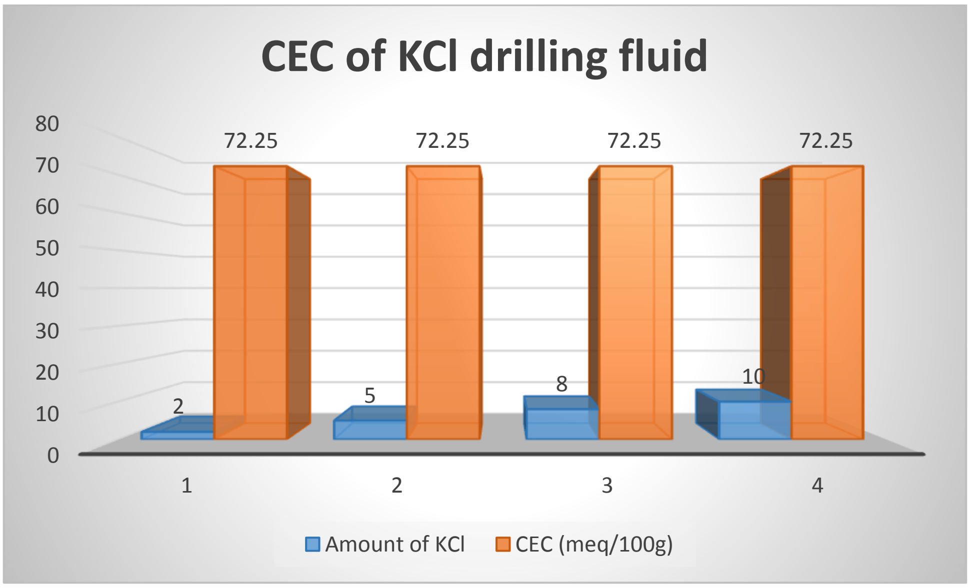


Fig. 5. CEC of KCl drilling fluid

Table No. 2 to Table No. 4 and Fig. 3 to Fig. 5 demonstrate that barite i.e. BaSO4, NaCl, and KCL, had no impact on altering the CEC value of the drilling fluid. This conclusion was made after doing the MBT test for each additive in a variety of escalating amounts and evaluating their CEC value. When making drilling fluid, barite is typically utilised as a weighting material. Barite was not added to the bentonite drilling fluid that was used to prepare the drilling fluid samples for the subsequent stage of the experiments because barite had no effect on the CEC value of the drilling fluid, meaning that these samples contained only the clay particle, or bentonite, as well as the salts and the alkaline solution separately, without any weighing material. These samples were aged, and the CEC values that were detected after 3 and 7 days did not indicate any change in the samples' values.

Table 5. CEC value of 1 mol/lit NaOH solution in the base bentonite drilling fluid

Sl. No.	Aging time (days)	CEC value (meq/100g)
1	Day 0	69.50
2	Day 3	64.25
3	Day 7	55.25

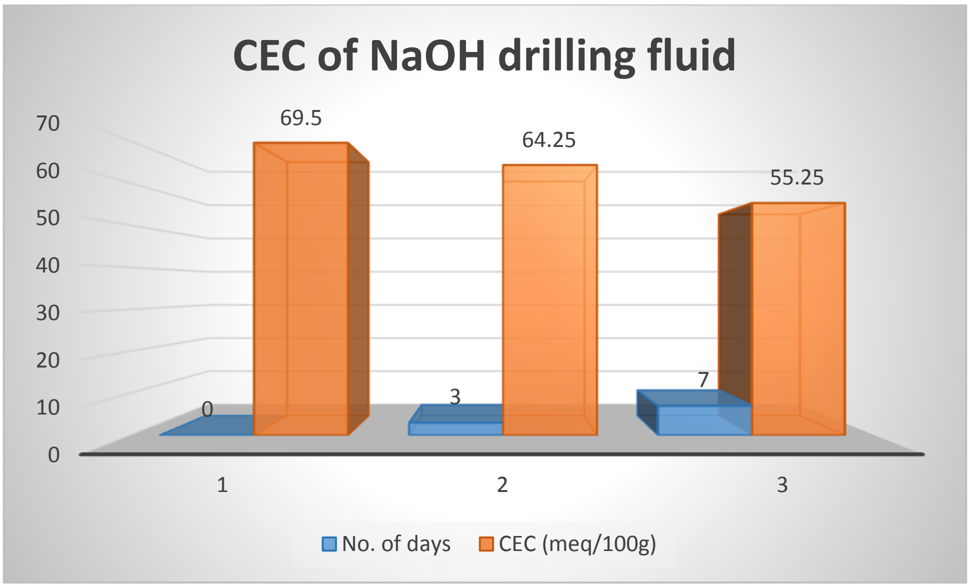


Fig 6. CEC of NaOH

When an alkaline solution was added to the base fluid, it was seen that the CEC value decreased, as seen in Table 5 and Fig. 6. With the passing of time, the CEC value progressively declined. In this experiment, the sample's CEC value varied from 69.50 to 55.25 meq/100g. Other writers (Jaqueline et al. 2013) have also noted a drop in the CEC value.

5. CONCLUSION

This study looked at how salt and an alkaline solution affected the drilling fluid's CEC value. Drilling fluids are colloids, and the CEC value calculation is crucial for the stability study of colloids. Stable colloids perform far better than unstable ones. Bentonite, a type of clay particle, barite, a weighing agent, salts like NaCl and KCl, and alkaline solution, or NaOH, are the ingredients used to prepare drilling fluid. The CEC value increased when the drilling fluid was made using bentonite and its concentrations were raised, which is a good sign for the stability of the drilling fluid because a higher CEC value indicates a more stable colloid. The CEC value of drilling fluid is unaffected by the weighting components, barite, and the salts NaCl and KCl. The CEC value does neither rise or decrease with their addition to the drilling fluid, which is a positive sign. It's because it doesn't drop the drilling fluid's CEC value, which shows that even while it doesn't act to stabilise the drilling fluid any more, it won't also cause a decrease in stability. After ageing for a while, barite, NaCl, and KCl have no effect at all on the CEC value of drilling fluid. Therefore, it can be said that the stability of the drilling remains consistent with the addition of these additives in any concentration and time. Alkaline solution responds very differently from these additives in contrast. The CEC value of the drilling fluid exhibits a drop in value with the addition of NaOH. This effect is seen as well as the drilling fluid sample ages. It is so abundantly evident that adding NaOH to drilling fluid reduces its stability, which is absolutely bad for a drilling fluid.

The conclusion drawn from this research is that, in addition to bentonite, additives like barite, NaCl, and KCl can be utilised to create drilling fluids that meet a variety of rheological property requirements without compromising the drilling fluid's stability. While caution should be used while using NaOH in drilling fluid, it should also be treated with additional additives to offset NaOH's influence on increasing the CEC value and counteract the drilling fluid's decreased stability.

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